

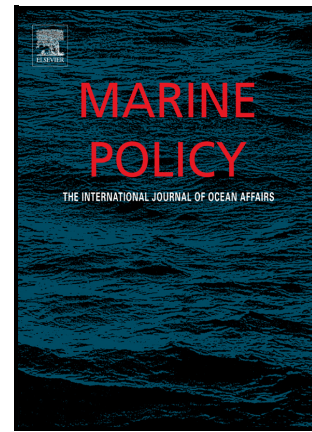


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Fatigue at sea during and after the COVID-19 pandemic: A comparative study of two matched samples of seafarers

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# **Fatigue at sea during and after the COVID-19 pandemic: A comparative study of two matched samples of seafarers**

## **Title page**

### **Title:**

Fatigue at sea during and after the COVID-19 pandemic: A comparative study of two matched samples of seafarers

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#### **Any Declaration of Interest statement**

None

#### **Abstract**

This paper examines seafarers' experience of fatigue during and after the pandemic. A multi-phase mixed methods research design was used, including two quantitative surveys ( $N_{\text{during-pandemic}}=501$  and  $N_{\text{after-pandemic}}=412$ ) and 36 in-depth interviews. Applying propensity score matching the two samples to approximate the conditions of a randomized controlled experiment, the study shows that surprisingly seafarers reported higher levels of fatigue after the pandemic. Qualitative interviews with seafarers and ship managers reveal the underlying reason – the intensified ship inspection regime together with policy and regulatory updates/revisions in the immediate aftermath of the pandemic increased seafarers' workload and made seafarers more fatigued. The results of the two surveys also show that while fatigue risk factors differed between the two periods, fatigue risk can be managed and mitigated in both periods by implementing fatigue risk management policies and practices. Policy and management implications for improving seafarers' occupational health and safety are discussed at the end of the paper.

**Keywords:** COVID-19 pandemic; fatigue; mixed methods; occupational health and safety; paradox theory; safety inspection

#### **1. Introduction**

Fatigue is a major contributing factor to workplace and transport-related accidents, injuries and fatalities (Williamson et al., 2011). It has long been a safety concern in the shipping industry (Bhattacharya & Tang, 2013; Dohrmann & Leppin, 2017; Jepsen et al., 2015; Tang et al., 2013; Wadsworth et al., 2008; Zhao et al., 2020). Fatigue is caused by a number of factors, such as long working hours, high work demands, poor sleep, long periods of service on board, and poor working conditions (Gander et al., 2011; Jepsen et al., 2015; Tang & Zhang, 2021). During the COVID-19 pandemic, the uncertainties associated with crew changes, lack of shore leave, and the risk of

contracting the virus resulted in mental health issues and worsened the problem of fatigue among seafarers at sea (Brooks & Greenberg, 2022). Unsurprisingly, the Seafarers' Happiness Index showed that seafarers' happiness in early 2022 fell to its lowest point of 5.85 (out of 10) since it was launched in 2015 (The Mission to Seafarers, 2023).

Fortunately, 2022 also saw the gradual lifting of pandemic restrictions around the world, signalling post-pandemic normality. For seafarers, especially towards the end of 2022, shore leave and access to welfare facilities ashore were steadily restored, and the certainty and stability of crew changes returned. By the end of 2022, their happiness level had risen to 7.69, even higher than the pre-pandemic level in 2019 (The Mission to Seafarers, 2023). This increase may reflect the removal of pandemic restrictions and the associated fatigue factors, and thus it is reasonable to assume that the removal would lead to a reduction in seafarers' fatigue levels. Nevertheless, this assumption needs to be validated empirically. In addition, it is unknown whether the transition to the post-pandemic era has any unexpected effects on seafarers' fatigue. It is well known that tensions are inherent in organisations due to multiple and conflicting demands (Smith & Lewis, 2011). In fact, fatigue can be seen to reflect the tension between cost/profit and safety (Bhardwaj et al., 2019; Tang & Zhang, 2021; Xue et al., 2017), which can be explained by paradox theory (Smith & Lewis, 2011). According to this theory, tensions are inherent in organisations because they have multiple and often incompatible goals to achieve. Furthermore, it argues that changes and transitions can bring latent tensions to the fore and create the need to manage them. As such, periods of change can provide a magnifying lens through which organisational tensions and the related management issues can be explored. While there is a large body of literature on the impact of the pandemic on seafarers, the post-pandemic transition has not been studied. Certainly the transition has ended the restrictions and is welcome as evidenced by the happiness index, but it should not be taken for granted that the transition would be problem-free.

In this context, this paper reports and discusses the results of a comparative study of Chinese seafarers' experiences of fatigue based on two surveys conducted in two phases – during and after the pandemic. To compare self-reported fatigue levels, data from the two samples (Sample A during the pandemic and Sample B after the pandemic) were matched based on respondent and work-related characteristics using propensity scores. In addition, factors associated with fatigue in the two samples were analysed separately. To ensure a robust interpretation of the survey results, qualitative interviews with seafarers and ship managers were conducted following the surveys. This mixed-methods and comparative approach helps to uncover unexpected fatigue issues at the beginning of the post-pandemic era.

## 2. Fatigue and the pandemic in the maritime context

According to the International Maritime Organisation (IMO, 2019), fatigue can be defined as

A state of physical and/or mental impairment resulting from factors such as inadequate sleep, extended wakefulness, work/rest requirements out of sync with circadian rhythms and physical, mental or emotional exertion that can impair alertness and the ability to safely operate a ship or perform safety-related duties.

This definition reflects the most up-to-date knowledge of fatigue in the maritime domain and enumerates the key contributing factors identified in the research literature (Dohrmann & Leppin, 2017; Jepsen et al., 2015). The general fatigue literature tends to highlight three key factors (Gander et al., 2011; Williamson et al., 2011): 1) homeostatic factors (i.e. poor sleep quality and/or poor sleep quantity), 2) circadian factors (e.g. shift work patterns – night shift work is likely to cause fatigue as it disrupts circadian rhythms and negatively affects sleep, and 3) task-related factors (i.e. long working hours, high workload, and work intensification). In the maritime domain, additional factors related to the working environment have also been identified (Dohrmann & Leppin, 2017; Jepsen et al., 2015). These include psycho-social stressors (such as separation from family, loneliness on board, multi-national crews, and limited recreational activities), physical work environment factors (such as noise, vibration, ship motion, and light in the cabin, which inevitably affect sleep and thus cause fatigue), and prolonged service which leads to longer exposure to fatigue-related factors (Paukstat, Andrei, et al., 2022).

Recognising that tensions are inherent in organisations as they have multiple and often incompatible goals to achieve, Smith and Lewis (2011) develop a theory of paradox. According to this theory, multiple demands, times of change and limited resources are likely to create tensions and/or bring latent tensions to the surface. In line with this theory, the occupational health and safety literature suggests that the tension between investing in occupational health and safety and making a profit is even present, and has identified this tension as a major underlying factor in workplace injuries (Nichols, 1997; Walters & Bailey, 2013) and fatigue in the maritime industry (Bhardwaj et al., 2019; Bhattacharya & Tang, 2013; Tang & Zhang, 2021; Xue et al., 2017). To achieve long-term development, Smith and Lewis' (2011) paradox theory suggests that rather than denying tensions, organisations need to accept and manage them effectively.

In the maritime industry, a number of international regulations have been adopted, requiring shipping companies to invest and develop capacity in fatigue management. Both the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) adopted by the IMO and the Maritime Labour Convention (MLC) adopted by the International Labour Organisation (ILO) set limits on seafarers' work and rest hours. However, as fatigue is caused by multiple factors, it is suggested that hours of service regulations are not sufficient and that a fatigue management system approach should be adopted (Gander et al., 2011). The system approach involves a fatigue management policy, education and awareness training, fatigue level monitoring, fatigue reporting mechanisms, and fatigue incident reporting and investigation procedures. Indeed, the International Safety Management (ISM) Code adopted by the IMO requires shipping companies to develop safety management systems (SMS) to manage safety (including fatigue) in a systematic manner.

The recent COVID-19 pandemic had a prolonged impact on the maritime industry (Bai et al., 2022; Tang, 2022b, 2022a; Zhao & Tang, 2023), and posed challenges for fatigue management as it caused a crew change crisis and shore leave restrictions for seafarers. During the pandemic, qualitative studies (Kaptan & Kaptan, 2021; Slišković, 2020) showed that, the uncertainties associated with crew change caused stress, anxiety, depression, fatigue and even suicidal thoughts among seafarers at sea. Similarly, quantitative studies showed that a large number of seafarers suffered mental health problems and fatigue (Hebbbar & Mukesh, 2020; Pauksztat, Grech, et al., 2022). For example, Hebbbar and Mukesh (2020) surveyed 288 seafarers, of whom 40 percent felt unhappy, 30 percent endured stress and over 15 percent felt completely fatigued. Fatigue was reported being associated with poor sleep. In Pesel et al.'s (2020) survey of 72 seafarers during their ship's call at the Port of Trieste, 30 percent of participants reported suffering from insomnia to the extent that they were concerned. Similar findings were also reported by other researchers (Kaptan & Kaptan, 2021; Slišković, 2020). As such, mental health problems, such as anxiety and depression, which were exacerbated by the pandemic (Baygi et al., 2021; Pauksztat, Andrei, et al., 2022), had a negative impact on seafarers' sleep quality. Furthermore, the pandemic resulted in extended services for many seafarers and increased workload due to additional tasks such as disinfection (Pauksztat, Grech, et al., 2022; Zhao et al., 2023). All these factors contributed to fatigue during the pandemic.

As noted above, pandemic-related restrictions were largely lifted in late 2022. With crew changes, shore leave and access to welfare facilities ashore returning to normal, seafarers' happiness had risen to high levels by the end of the year (The Mission to Seafarers, 2023). In this context, it is reasonable to formulate a hypothesis:

Hypothesis: the mean levels of fatigue reported by seafarers after the COVID-19 pandemic will be lower compared to the mean levels of fatigue reported by the sample during the pandemic.

More broadly, this paper also draws on paradox theory (Smith & Lewis, 2011) to examine fatigue risk factors during and after the pandemic and the related management issues. During the pandemic, although shipping companies took various measures to support seafarers (Tang et al., 2022), the pandemic-related fatigue factors, such as mental health problems, extended tour of duty, limited shore leave, and pandemic-induced additional workload, were largely beyond the control of individual companies. As such, these factors could play a significant role in causing fatigue. They reflect the tension between public health and seafarers' occupational health and safety. In the aftermath of the pandemic, these factors have generally been removed. Nevertheless, the fatigue problem remains, since the traditional factors associated with the working environment and conditions, such as work intensification, shift work, and ship motion and vibration are still present and need to be managed. Furthermore, as suggested by the paradox theory (Smith & Lewis, 2011), in times of change, new demands (or changes in demands) from multiple stakeholders can place constraints on limited resources and bring latent tensions to the surface. In the context of this study, it is reasonable to assume that such tensions may have an impact on fatigue management and affect seafarers' experience of fatigue. As such, the main fatigue contributing factors would differ during and after the pandemic. To identify the differences and explore the implications for fatigue management, a research question can be formulated: what are the main fatigue contributing factors during the two periods?

Before discussing the research methods, it is necessary to draw a line between during and after the pandemic in the context of this paper. After three years of implementing strict pandemic control measures, China reopened its borders and lifted travel restrictions on 8 January 2023, marking the end of the zero-COVID policy and a return to the post-pandemic normality (Zhou & Tian, 2023). As such, in relation to Chinese seafarers in this paper, 'during the pandemic' refers to the period from January 2020 to 7 January 2023, and the post-pandemic era begins on 8 January 2023. For seafarers of other nationalities, the 'after pandemic' start date is less clear-cut, but can be seen to start from mid-2022 when most countries began to gradually open their borders.

### **3. Research methods**

This research was conducted with two Chinese state-owned shipping companies. At the time of the research, Company A operated more than 300 container ships sailing

on 357 international and domestic routes. Company B operated more than 300 dry bulk ships trading worldwide. Both companies directly employed around 10,000 officers and ratings on fixed-term contracts (5–8 years), all of whom are Chinese. They also recruited some ratings through crewing agencies on short-term tour-of-duty contracts. As state-owned companies with government financial support, the two companies provided directly employed seafarers with better social security coverage, more fringe benefits, and better working conditions than companies with other forms of ownership (Chen & Tang, 2022).

This research adopted a multi-phase mixed methods research design involving two quantitative surveys and 36 in-depth interviews. Both surveys used the same questionnaire, which is a revised version of the questionnaire used in the Cardiff Seafarers' Fatigue Research Programme (Smith et al., 2006). The questions were designed to explore the perceived fatigue levels of seafarers as well as the organisational and individual factors associated with fatigue. Survey A was conducted during the COVID-19 pandemic between November and December 2022. The questionnaire was distributed via email to all the 581 seafarers working on 25 ships of the companies and 501 of them (86.3%) participated and returned the survey questionnaire. Survey B was conducted after the pandemic between mid-January and the end of February 2023. The questionnaire emailed to all the 488 seafarers working on 21 of the companies' ships and 412 of them (84.5%) returned the questionnaire. A total of 913 seafarers completed the questionnaire, including 442 officers (48.4%) and 438 ratings (48%). In terms of department, 386 participants (42.3%) were from the deck department and 480 (52.6%) were from the engine department. Their ages ranged from 23 to 59, with an average age of 34.6. Since the shipping companies only recruited male seafarers, all participants were male.

Fatigue is an integration of subjective perception, performance and physiological functioning, making its measurement complex. To capture both the intensity and frequency of perceived physical and mental fatigue, we used the mean of five aspects of acute fatigue (see Appendix Table A). It should be noted that physical fatigue is measured by item 4, and mental fatigue by item 5, in Table A. In addition, a full list of the measures used in the analyses representing the demographic and work-related characteristics of the seafarers is provided in Appendix Table B. These have been identified in previous research as factors associated with fatigue (Dohrmann & Leppin, 2017; Jepsen et al., 2015; Zhao et al., 2020).

To provide a contextual explanation of the survey results, semi-structured interviews were conducted with 12 managers (6 from each company) and 24 seafarers (12 from each company) following Survey B in 2023. The interviews explored whether and how

the lifting of the pandemic restrictions affected seafarers' work and life on board and their experience of fatigue. The interviews were conducted online, and informed consent was obtained verbally from all the interviewees. Participants were anonymised. Ethical approval for this research was granted by the Psychology Ethics Committee of Dalian Maritime University. Interviews were audio recorded and transcribed. Analyses were conducted using the NVivo software package and organised around key emerging themes.

## 4. Analyses and results

### 4.1. Comparison of reported fatigue levels using propensity scores

For the comparison between the two survey samples, a binary variable (treatment) was added to distinguish them. The 2022 sample (Survey A) was considered as the control group and the 2023 sample (Survey B) as the treatment group. The 2023 sample was then matched to the other one in order to reduce bias due to differences in respondent and work-related characteristics between the two samples. Nine variables were chosen according to the disjunctive cause criterion to match the samples (VanderWeele, 2019; VanderWeele & Shpitser, 2011). These selected variables were either independent of pandemic restrictions or affected the outcome of pandemic restrictions (i.e., fatigue) (Pauksztat, Andrei, et al., 2022).

- 1) Age
- 2) Crew number
- 3) Rank
- 4) Department
- 5) Experience at sea
- 6) Standing when on watch
- 7) Training on fatigue
- 8) Sleep periods per day
- 9) Rest before sailing

Propensity score matching was used to estimate the average marginal effect of the removal of pandemic control on seafarers' fatigue. The propensity score was estimated using logistic regression with option "glm" in R package MatchIt. This provided adequate balance (Table 1), as indicated by an overall standardized mean difference of 0.0068 and standardized mean differences for all covariates below 0.13.

Table 1 Sample means and balance information

	Survey A: original sample	Survey A: matched sample	Survey B sample	Balance for matched data				
				<i>Std. mean diff. (original)</i>	<i>Std. mean diff.</i>	<i>Varia nce ratio</i>	<i>eCDF mean distance</i>	<i>eCDF maximum distance</i>
<i>Mean</i>	<i>Mean</i>	<i>Mean</i>						

Distance	0.5662	0.5034	0.5023	0.9186	0.006 8	1.005 2	0.0027	0.0436	0.0034
Age	2.3964	2.4036	2.3782	-0.1944	0.028 6	1.127 0	0.0240	0.0473	0.8838
Crew number	2.8953	2.9891	2.9964	-0.4010	- 0.015 1	1.204 4	0.0116	0.0291	0.1639
Rank	0.8151	0.9818	1.0036	-0.3835	- 0.022 3	0.985 1	0.0073	0.0182	0.7779
Departm ent	0.5568	0.5564	0.5855	-0.1358	- 0.051 9	1.175 7	0.0242	0.0509	0.7224
Experien ce at sea	2.0735	2.0691	2.1382	-0.0451	- 0.044 6	1.108 7	0.0141	0.0400	0.7392
Standing on watch	0.7996	0.7127	0.7236	0.6218	- 0.027 2		0.0109	0.0109	0.8054
Training on fatigue	0.6860	0.6327	0.6909	-0.0493	- 0.125 4		0.0582	0.0582	0.6118
Sleep periods per day	0.9773	1.0036	1.0036	-0.1570	0.000 0	0.855 1	0.0121	0.0182	0.5310
Rest before sailing	0.6726	0.6327	0.6073	0.1475	0.054 2		0.0255	0.0255	0.6849

To estimate the treatment effect and its standard error, linear regression with acute fatigue as the outcome was then performed using SPSS version 27. The model included the treatment effect and the covariates used for the matching. The results are shown in Table 2.

Table 2 Estimating the impact of the lifting of pandemic restrictions on acute fatigue

	Fatigue <i>b (SE)</i>
Intercept	3.340(0.368)
The release of pandemic control	0.275*** (0.069)
Age	-0.156(0.049)
Crew number	-0.038(0.095)
Rank	-0.148(0.036)
Department	-0.109(0.063)
Experience at sea	-0.063(0.032)
Standing when on watch	0.056(0.084)
Training on fatigue	-0.218*** (0.075)

Sleep periods per day	-0.100(0.070)
Rest before sailing	-0.240*** (0.075)

The results indicate a significant treatment effect for acute fatigue ( $b = 0.275$ ,  $SE = 0.069$ ,  $p < .001$ ), indicating significantly higher average levels of reported fatigue after the pandemic than during the pandemic.

The self-reported levels of acute fatigue, physical fatigue (measured by item 4 in Table A) and mental fatigue (measured by item 5 in Table A) in the two matched samples were also compared. The results (see Table 3) show that the means for acute fatigue, physical fatigue and mental fatigue were all significantly higher in the Survey B sample.

This suggests that seafarers reported higher levels of fatigue after the pandemic than during it. The results do not support the hypothesis. In fact, they support the opposite, that is, the mean levels of fatigue reported by seafarers after the COVID-19 pandemic are significantly higher than the mean levels of fatigue reported by the sample during the pandemic.

Table 3 Comparison of fatigue levels between Survey A and Survey B respondents.

		N	Mean	SD	Sig
Physical fatigue	Survey A	275	1.4718	0.90639	0.000
	Survey B	275	1.9806	0.84877	
Mental fatigue	Survey A	275	1.4978	0.98302	0.000
	Survey B	275	1.9180	0.89554	
Acute fatigue	Survey A	275	1.58381	0.836166	0.033
	Survey B	275	1.80968	0.686037	

#### 4.2. Fatigue factors

To address the research question, stepwise regressions were conducted using SPSS version 27. Data from Survey A and Survey B (the original rather than the two matched samples) were analysed separately. All variables were added simultaneously. Table 4 and Figure 1 show the top 3 factors (ranked by B value) associated with acute fatigue during the pandemic. Table 5 and Figure 2 show the top 3 (direct) factors (ranked by B value) associated with acute fatigue after the pandemic. The top 2 underlying factors (ranked by B value) associated with each of the identified (direct) factors were also analysed in order to explore how seafarers' fatigue was related to management strategies.

Table 4 Stepwise regression with acute fatigue during the pandemic

Associated factors	Fatigue	<i>b</i> ( <i>SE</i> )
Supplies to vessel and crew (in port)	Acute Fatigue	-0.194* (.079)
A lack of shore leave	Acute Fatigue	0.183* (.081)
Training on fatigue	Acute Fatigue	-0.138* (.059)

Note. Unstandardized coefficients and standard errors, based on data from 501 respondents. \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ . Fatigue factors are listed and ranked by B value.

#### During the pandemic

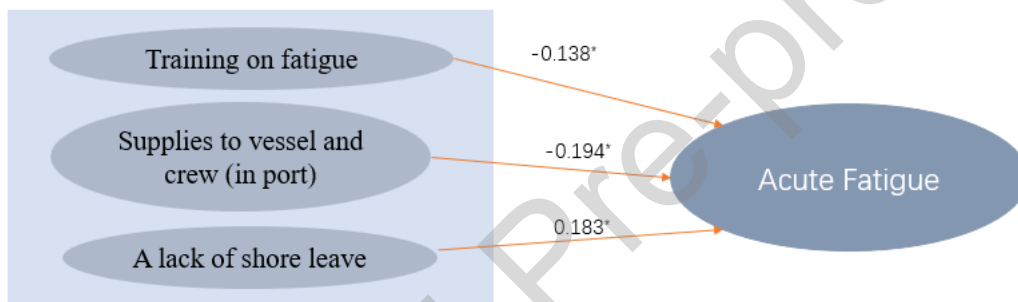


Fig.1. Visualization of the structural equation model in Table 4, showing the significant paths ( $n = 501$ ).

Table 4 and Figure 1 show significant negative associations between acute fatigue and two factors: training on fatigue ( $b = -.138$ ,  $SE = .059$ ,  $p = .021$ ) and supplies to vessel and crew (in port) ( $b = -.194$ ,  $SE = .079$ ,  $p = .014$ ), and a significant positive association between acute fatigue and a lack of shore leave ( $b = .183$ ,  $SE = .081$ ,  $p = .024$ ). These results suggest that during the pandemic, training on fatigue, providing sufficient supplies while the ship is at berth, and allowing/arranging shore leave helped to reduce acute fatigue. While the first factor was related to fatigue risk management, the latter two were related to pandemic restrictions.

Table 5 Stepwise regression with acute fatigue and with the identified factors after the pandemic

Note. Unstandardized coefficients and standard errors, based on data from 412 respondents. \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ . Fatigue factors are listed and ranked by B value.

	Associated factors	Outcome	<i>b</i> (SE)
Part A	Your state when you arrived at your most recent vessel ready for your new tour of duty	Acute Fatigue	0.260*** (0.052)
	Have difficulty getting up	Acute Fatigue	0.212*** (0.050)
	Have difficulty falling asleep	Acute Fatigue	0.209*** (0.058)
Part B	Effectiveness of fatigue risk management system	Your state when you arrived at your most recent vessel ready for your new tour of duty	-0.340*** (0.050)
	Experiences at sea	Your state when you arrived at your most recent vessel ready for your new tour of duty	-0.122* (0.052)
	Training on fatigue	Have difficulty falling asleep	-0.624** (0.201)
	Policy on working hours	Have difficulty falling asleep	-0.563* (0.257)
	Policy on working hours	Have difficulty getting up	2.257* (0.892)
	Experiences at sea	Have difficulty getting up	-0.242*** (0.061)

#### After the pandemic

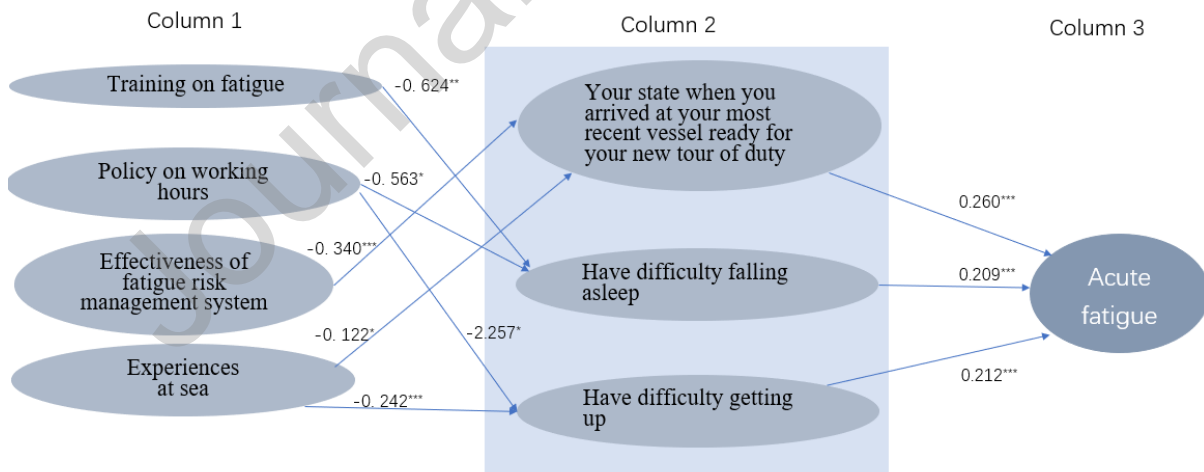


Fig.2. Visualization of the structural equation model in Table 5, showing the significant paths (n =412).

Table 5 (Part A) and Figure 2 (Columns 2 and 3) show that after the pandemic, the top 3 (direct) factors significantly associated with acute fatigue were: Your state when you arrived at your most recent vessel ready for your new tour of duty ( $b = 0.260$ ,  $SE = 0.052$ ,  $p < .001$ ), Have difficulty falling asleep ( $b=0.209$ ,  $SE=0.058$ ,  $p < .001$ ) and

Have difficulty getting up ( $b=0.212$ ,  $SE=0.050$ ,  $p < .001$ ). This suggests that if seafarers arrived at their ship tired and if they felt they had difficulty falling asleep and getting up, they were more likely to feel fatigued.

A further question is what underlying factors were associated with the (direct) factors identified above. To explore this question, stepwise regressions were run with the top 3 (direct) factors as dependent variables. The results are shown in Part B of Table 5, and in Columns 1 and 2 of Figure 2.

Regarding the factor: Your state when you arrived at your most recent vessel ready for your new tour of duty, the regression results show that the top 2 underlying factors were the effectiveness of Fatigue Risk Management System ( $b=-0.340$ ,  $SE=0.050$ ,  $P < .001$ ) and Experience at sea ( $b=-0.122$ ,  $SE=0.052$ ,  $P=.020$ ). This suggests that the more effective the company's Fatigue Risk Management System was and the more experienced the seafarers were, the less likely seafarers were to feel fatigued when they arrived at their vessel to start their tour of duty.

In relation to the factor - Have difficulty falling asleep, the regression results show that the top 2 underlying factors were Training on fatigue ( $b=-0.624$ ,  $SE=0.201$ ,  $p=.002$ ) and having policy on working hours ( $b=-0.563$ ,  $SE=0.257$ ,  $p=.031$ ). This suggests that training on fatigue and having working hour policy were associated with lower frequency of having difficulty falling asleep.

Regarding the factor – Have difficulty getting up, the regression results show that the top 2 underlying factors were having policy on working hours ( $b=-2.257$ ,  $SE=0.892$ ,  $p=.012$ ) and Experience at sea ( $b = -0.242$ ,  $SE = 0.061$ ,  $p < .001$ ). This suggests working hour policy and more experience at sea were associated with a lower frequency of feeling fatigued.

In summary, in the aftermath of the pandemic, seafarers' fatigue, through its association with sleep quality and sleep disturbance, is fundamentally related company's fatigue risk management policies and practices (including training on fatigue, policy on working hours and effectiveness of fatigue risk management) and seafarers experience at sea. The more effective the management strategies were and the more experience they have at sea, the less likely seafarers were to report fatigue. These findings, however, do not explain why seafarers' fatigue levels increased after the pandemic. To shed light on this issue, we next examine the interview data.

#### 4.3. Interview findings

During the pandemic, in compliance with the zero-COVID policy, Chinese shipping companies required their seafarers must wear anti-viral PPE<sup>1</sup> when working on deck and the ship was docked. They also did not allow seafarers to take any shore leave, fearing that seafarers might catch the virus ashore or bring it back to China. Although the restrictions were officially lifted after the pandemic, seafarers reported that in many cases, Chinese port authorities continued to require seafarers to wear a N95 mask and gloves while in port and to prohibit shore leave. Similarly, Chinese shipping companies, especially large ones, discouraged their seafarers from taking shore leave, stating that seafarers would be held responsible for any consequences if they went ashore and contracted COVID-19. A chief officer reported:

After three years of draconian pandemic control, we are eager to visit a port with no pandemic restrictions. At the moment, however, some Chinese ports still have some precautionary measures in place, and in some cases we are still not allowed to go ashore. We are still required by the company and the port authority to wear N95 masks and gloves when working in the port. We are very tired of this. It is not good for reducing our work pressure and it is bad for our mental health.

The underlying reason is safety. COVID-19 spreads rapidly, and it is estimated that 80% of Chinese people were infected six weeks after the lockdown measures were lifted (Parkinson, 2023). It is reasonable to assume that if one seafarer caught the virus, the whole ship would quickly be infected. Although the new strains tended to cause only mild symptoms, a large number of crew members falling ill at the same time would inevitably affect the safe operation of the ship. From this perspective, the restrictions may be understandable. However, they have been shown to exacerbate fatigue (Brooks & Greenberg, 2022). As such, the restrictions create a paradoxical tension between fatigue and safety.

This tension is also reflected in safety inspections. During the pandemic, ship inspections, including port state control (PSC), flag state and company inspections, were carried out remotely. The lifting of the pandemic restrictions allowed the return of shipboard inspections. In relation to company inspection, a manager from Company A explained:

During the pandemic, we did not have the opportunity to go on board and find out what was going on. Now that it is open, one of our most important tasks is to get the latest information on the situation on board as quickly as possible. This is also a kind of humanistic care for our crew.

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<sup>1</sup> PPE refers to personal protective equipment, consisting of four items: a pair of disposable medical gloves, an N95 mask, a hazmat suit, and a pair of protective goggles.

From their perspective, however, seafarers reported that different types of physical inspections were resumed at the same time and were carried out one after another at short intervals. Without any doubt, the inspection regime aims to ensure maritime safety and research shows that it has improved the maritime safety records over the years (Tang & Zhang, 2021). However, the intensified regime following the lifting of restrictions has also led to fatigue. A captain said:

Following the COVID-19 pandemic, shipowners, flag States, port States and other relevant organisations have gradually resumed on-site ship inspections. However, as the pandemic has virtually prevented physical inspections for the past three years, all physical inspections are now being resumed and concentrated in this period. This leads to a sharp increase in our workload and pressure to prepare for all these inspections. This also disrupts our work pattern and rhythm in port, resulting in fatigue and potential safety hazards to navigation. We hope that the relevant organisations could consider coordinating the inspection time and adopt a method of combining remote inspection and on-site boarding inspection to reduce the inspection time in port and reduce the work pressure and workload of seafarers.

Furthermore, post-pandemic policies and requirements for ship and port operations differ around the world. Seafarers had to quickly learn and adapt to the new safety regulatory environment and requirements, further exacerbating the fatigue problem. A third officer said:

Each time the ship calls at a port, we have to learn new regulations and requirements. Although they are all based on IMO conventions, each port makes its own adjustments. As we are already very busy in port, we have to learn new rules, fill in different forms and prepare for strict inspections in a short period of time. This adds to the workload and makes us very tired.

In addition, seafarers were required to learn the company's policies, which had been revised and updated to reflect the policy changes made by the Chinese maritime authorities. A manager from Company B said: 'We always sent the latest policies on board and required our seafarers to learn them to ensure they were up to date.' However, the seafarers saw this as a burden, as a second engineer pointed out:

Too many documents were sent to the ship, some of which were not directly related to our work. But our company required us to learn them and checked how we had learnt them. This is not really necessary. It is just a waste of time.

Internet connectivity was found to alleviate fatigue problems and promote occupational health and safety during the pandemic (Pauksztat, Grech, et al., 2022). In this study, although seafarers were provided with more free Wi-Fi data, they complained that it was mostly used to download and learn company policy updates rather than to communicate with family on shore. Thus, in this case, internet connectivity increased the demand on seafarers' work/learning time, leading to fatigue. A chief engineer complained:

The IMO conventions, the guidelines and regulations issued by the Chinese maritime authorities... more and more documents that we have to learn. The company also checks how we have learnt and implemented the requirements via the wireless network on board. The consequences of non-compliance are very serious. We are only given a few tens of megabytes per month, all of which is used for the company's inspection.

## 5. Discussion

Drawing on data from two surveys of seafarers' experience of fatigue – Survey A during the pandemic and Survey B after the pandemic, this paper shows that, unexpectedly and alarmingly, seafarers' fatigue levels increased after the pandemic, despite the removal of pandemic-related fatigue factors. Regression analysis of Survey A data shows that, factors related to pandemic restrictions, such as lack of shore leave and insufficient supplies increased fatigue levels, while training on fatigue helped reduce fatigue levels. The results corroborate previous research findings that the pandemic posed challenges for fatigue management in the maritime industry (Hebbar & Mukesh, 2020; Kaptan & Kaptan, 2021; Pauksztat, Grech, et al., 2022; Slišković, 2020). Regression analyses of Survey B data show that fatigue risk factors changed after the pandemic. During this period, seafarers' reported fatigue levels were directly related to factors such as sleep problems (difficulty falling asleep and getting up) and whether they were tired when they arrived at the ship to start work, and these factors were in turn related to the company's fatigue risk management strategies (including training on fatigue, policy on working hours and the effectiveness of fatigue risk management) and seafarers' experiences at sea. These findings also confirm previous research that effective fatigue risk management helps to reduce fatigue levels and that working arrangements and conditions have significant implications for seafarers' occupational health and safety (Gander et al., 2011; Zhao et al., 2020).

Although the results of the regression analyses are consistent with previous research, they do not provide an explanation as to why seafarers felt more fatigued after the pandemic. In this context, the interview results complement the survey results and shed light on the issue. They suggest that in the immediate aftermath of the pandemic, seafarers were required to continuously comply with pandemic preventive measures in some ports, to cope with concentrated ship inspections, and to learn and adapt to

various newly updated port regulations and company policies. All of this increased their workload and contributed to fatigue in the name of safety.

Overall, this multi-phase mixed methods study reveals paradoxes and tensions in relation to fatigue management in the shipping industry. Firstly, the removal of pandemic restrictions (and the associated fatigue risk factors) has led to seafarers reporting higher levels of fatigue. Underlying this first paradox is the second one – while the demands of complying with the intensified safety inspection regime and adapting to policy changes were intended to improve safety, they nevertheless increased seafarers' workload and reduced their rest periods. This creates a tension between safety and fatigue. The paradox of seafarers being fatigued by safety inspections has been discussed in previous research (Bhattacharya & Tang, 2013). Drawing on paradox theory (Smith & Lewis, 2011), this paper adds to the discussion by showing that a period of transition brings with it the need to adapt quickly to changes in the environment, which puts a strain on resources and brings tensions to the surface.

Returning to the results of the regression analyses of the two surveys, they show that training on fatigue led to lower fatigue levels both during and after the pandemic. They also show that after the pandemic, a number of fatigue risk management measures (training on fatigue, working hour policy and fatigue risk management system) helped seafarers to get better rest, thereby reducing fatigue levels and promoting seafarers' occupational health and safety. These findings suggest that while the paradoxical tensions that can cause fatigue cannot be eliminated, fatigue risk can be managed and mitigated through the implementation of fatigue risk management policies and practices.

## 6. Conclusion

This paper takes the initiative to examine seafarers' experiences of fatigue during the transition to the post-pandemic normality. Using propensity score matching, data from the two surveys conducted during and after the pandemic show that surprisingly seafarers reported higher levels of fatigue after the pandemic. Qualitative interviews with seafarers and ship managers following the surveys reveal the underlying reason – the intensified ship inspection regime together with policy and regulatory updates/revisions in the aftermath of the pandemic increased seafarers' workload and made it difficult for them to get good rest. The results of the two surveys also show that the fatigue risk factors were different during and after the pandemic. During the pandemic, risk factors tended to be related to pandemic restrictions. After the pandemic, risk factors were more likely to be related to the company's fatigue risk management policies and practices.

This paper sheds new light on fatigue management in the shipping industry. Drawing on paradox theory (Smith & Lewis, 2011), it shows that the transition to the post-

pandemic normality exacerbates the tension between addressing safety concerns (a concentration of various ship inspections in a short period) and fatigue risk management. It also demonstrates that this tension and fatigue risk can be mitigated by adopting effective fatigue risk management policies and practices.

These findings have both policy and management implications. To safeguard seafarers' occupational health and safety in general, at the policy level, ship inspection authorities should coordinate their inspection activities to reduce disruptions to seafarers' busy schedules in port. Efforts by national maritime administrations to develop and revise maritime and port policies and regulations should be streamlined and coordinated with international organisations. At the level of company management, it is important to monitor seafarers' fatigue during periods of change and transition, to assess whether changes in demand will exacerbate stress, and to provide adequate training to manage and reduce stress and fatigue risk. According to paradox theory (Smith & Lewis, 2011), tensions cannot be eliminated due to multiple and conflicting demands, so organisations need to accept and manage them proactively to achieve sustainable development. In the context of managing fatigue issues, as suggested by Gander et al. (2011), organisations should adopt a systematic approach and implement a fatigue management system, which would include a fatigue management policy, education and awareness training, fatigue level monitoring, fatigue reporting mechanisms, and fatigue incident reporting and investigation procedures.

It is worth noting that this research has limitations. It focuses on two Chinese shipping companies and the samples are not representative. However, being large and state-owned, the two companies have more financial resources to manage fatigue than smaller and non-state-owned shipping companies. If they find it difficult to manage fatigue, other companies with fewer resources are likely to find it more difficult. Future research can extend the focus to seafarers and shipping companies of other nationalities to explore the issue further.

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## Appendix

**Table A The five items to measure acute fatigue**

1	Which of the following responses best describes your typical state during work? Scored 0 (very alert) to 4 (sleepy).
2	About how often do you feel tired at work? Scored 0 (never) to 4 (about everyday).
3	About how often do you feel sleepy at work? Scored 0 (never) to 4 (about everyday).
4	In a normal workday, how physically tired do you usually feel at the end of the working day? Scored 0 (Not at all) to 4 (Extremely).
5	On a normal working day, how mentally tired do you usually feel at the end of the working day? Scored 0 (Not at all) to 4 (Extremely).

**Table B Descriptive statistics of during and post pandemic samples across demographic and work-related characteristics**

Measures	During pandemic	Post pandemic
1. Supplies to vessel and crew (in port) Yes, enough supplies No, insufficient	84.4% (422) 15.6% (78)	89.2% (364) 10.8% (44)
2. Have shore leave in port Yes, have shore leave Sometimes Almost no shore leave	2.0% (10) 2.8% (14) 95.2% (477)	78.7% (322) 20.5% (84) 8% (3)
3. Training on fatigue Yes, have fatigue training No training	71.1% (356) 28.9% (145)	70.4% (285) 29.6% (120)
4. Over contract Always take the annual leave on time Occasionally delayed Always delayed	26.5% (133) 53.3% (267) 20.2% (101)	54.6% (221) 39.6% (161) 5.8% (23)
5. Sleep before starting work on board Yes, we have the opportunity to sleep No, we don't	61.3% (307) 38.7% (194)	66.7% (273) 33.3% (136)
6. Your state when you arrived at your most recent vessel ready for your new tour of duty Not fatigued Slightly tired Moderately tired Very tired Extremely tired	50.3% (252) 25.7% (129) 13.4% (67) 6.8% (34) 3.8% (19)	51.2% (211) 34.7% (143) 8.3% (34) 3.9% (16) 1.9% (8)
7. Have difficulty falling asleep		

Not at all	9.8% (49)	26.9% (109)
A little	55.2% (277)	45.2% (183)
Quite a bit	28.8% (144)	21.7% (88)
Almost always	6.2% (31)	6.2% (25)
8. Have difficulty getting up		
Not at all	19.6% (98)	28% (113)
A little	41.4% (207)	39.6% (160)
Quite a bit	27.1% (136)	20.0% (81)
Almost always	12.0% (60)	12.4% (50)
9. Ship motion disturbing sleep		
Not at all	8.4% (42)	6.1% (25)
A little	43.2% (217)	33.6% (137)
Quite a bit	36.0% (180)	39.7% (162)
Very much	12.4% (62)	20.6% (84)
10. Wake up confused, disorientated, irritable		
Not at all	34.1% (171)	41.0% (167)
A little	38% (190)	35.4% (144)
Quite a bit	20.9% (105)	15.0% (61)
Almost always	7.0% (35)	8.6% (35)
11. Effectiveness of Fatigue Risk Management System		
Not effective	8.1% (41)	8.9% (21)
Somewhat effective	52.0% (261)	53.5% (124)
Very effective	39.9% (199)	38.6% (91)
12. Experiences at sea (in group)		
less than 5 years	43.7% (219)	53.8% (218)
6-10	25.1% (126)	19.5% (79)
11-15	15.2% (76)	12.1% (49)
16-20	8.0% (40)	6.9% (28)
21-25	1.6% (8)	3.5% (14)
26-30	2.6% (13)	3.0% (12)
31-35	1.6% (8)	0.7% (3)
more than 35	2.2% (11)	0.5% (2)
13. Policy on working hours		
Yes, we have the policy	90.2% (452)	89.4% (345)
No, we don't	9.8% (49)	10.6% (41)
14. Standing when on watch		
Yes	53.1% (266)	80.0% (328)
No	46.9% (235)	20.0% (82)
15. Sleep Periods per 24 hours		
1 sleep period	12.2% (61)	11.0% (45)
2 sleep periods	70.9% (355)	79.8% (327)
3 or more sleep periods	17.0% (85)	9.3% (38)
16. Age (in group)		
less than 25	13.4% (66)	11.8% (47)
26-35	36.3% (178)	52.9% (210)
36-45	33.0% (162)	21.4% (85)
46-55	16.9% (83)	12.1% (48)
more than 56	0.4% (2)	1.8% (7)
17. Rank		
Officer	38.3% (192)	61.9% (250)
Rating	61.7% (309)	38.1% (154)
18. Department		
Deck	39.5% (198)	48.0% (197)
Engineering	56.5% (283)	48.0% (197)

**CRedit authorship contribution statement**

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